

WHAT IS CLAIMED IS:

1. A high strength cold rolled steel sheet consisting essentially of 0.0040 to 0.01% C, 0.05% or less Si, 0.1 to 1.0% Mn, 0.01 to 0.05% P, 0.02% or less S, 0.01 to 0.1% sol.Al, 0.004% or less N, 0.01 to 0.14% Nb, and optionally 0.05% or less Ti, optionally 0.002% or less B, by weight, and a balance of substantially Fe and inevitable impurities; and satisfying the following formulae (6) and (7):

$$(12/93) \times \text{Nb}^*/\text{C} \geq 1.2 \quad (6)$$

$$\text{TS} - 4050 \times \text{Ceq} \geq -0.75 \times \text{TS} + 380 \quad (7),$$

wherein $\text{Nb}^* = \text{Nb} - (93/14) \times \text{N}$, $\text{Ceq} = \text{C} + (1/50) \times \text{Si} + (1/25) \times \text{Mn} + (1/2) \times \text{P}$,

TS denotes the tensile strength in MPa, and C, Si, Mn, P, N, and Nb denote the content in % by weight of carbon, silicon, manganese, phosphorus, nitrogen and niobium, respectively.

2. The high strength steel sheet of claim 1, further containing 0.05% or less Ti, by weight.
3. The high strength steel sheet of claim 1, further containing 0.002% or less B, by weight.

4. A high strength cold rolled steel sheet consisting essentially of: 0.0040 to 0.01% C, 0.05% or less P, 0.02% or less S, 0.01 to 0.1% sol.Al, 0.004% or less N, 0.03% or less Ti, by weight, and Nb in an amount satisfying the following formula (8):

$$1 \leq (93/12) \times (\text{Nb}/\text{C}) \leq 2.5 \quad (8),$$

wherein C and Nb denote the content in % by weight of carbon and niobium, respectively; the high strength cold rolled steel sheet having a volumetric proportion of NbC of 0.03 to 0.10%; and 70% or more thereof being in a size of 10 to 40 nm.

5. A method for manufacturing a high strength cold rolled steel sheet, comprising the steps of:

(a) preparing a continuous casting slab of a steel which consists essentially of 0.0040 to 0.01% C, 0.05% or less P, 0.02% or less S, 0.01 to 0.1% sol.Al, 0.004% or less N, 0.03% or less Ti, by weight, and Nb in an amount satisfying the following formula (8):

$$1 \leq (93/12) \times (\text{Nb}/\text{C}) \leq 2.5 \quad (8),$$

wherein C and Nb denote the content in % by weight of carbon and niobium, respectively;

(b) preparing a hot rolled steel sheet by finish rolling the slab from step (a) at reduction ratios satisfying the following formulae (9) through (11):

$$10 \leq \text{HR1} \quad (9)$$

$$2 \leq \text{HR2} \leq 30 \quad (10)$$

$$\text{HR1} + \text{HR2} - \text{HR1} \times \text{HR2}/100 \leq 60 \quad (11),$$

wherein HR1 and HR2 denote the reduction ratio in % in the finish rolling at the pass just before the final pass and the final pass, respectively;

(c) cold rolling the hot rolled sheet from step (b) and

(d) annealing the sheet from step (c).

6. A high strength steel sheet consisting essentially of 0.0040 to 0.010% C, 0.05% or less Si, 0.10 to 1.5% Mn, 0.01 to 0.05% P, 0.02 or less S, 0.01% to 0.1% sol.Al, 0.00100% or less N, 0.036 to 0.14% Nb, and optionally containing 0.0015% or less B, by weight, and satisfying the following formula (12):

$$1.1 < (\text{Nb} \times 12)/(\text{C} \times 93) < 2.5 \quad (12),$$

wherein C and Nb denote the content in % by weight of carbon and niobium, respectively; the high strength steel sheet having an average grain size of 10 μm or less and an r value of 1.8 or more.

7. The high strength steel sheet of claim 6, further containing 0.0015% or less B, by weight.

8. The high strength steel sheet of claim 6, further containing 0.019% or less Ti, by weight, and satisfying the following formula (13):

$$\text{Ti} \leq (48/14) \times \text{N} + (48/32) \times \text{S} \quad (13),$$

wherein N, S, and Ti denote the content in % by weight of nitrogen, sulfur, and titanium, respectively.

9. The high strength steel sheet of claim 8, further containing 0.0015% or less B, by weight.

10. A method for manufacturing a high strength cold rolled steel sheet, comprising the steps of:

(a) preparing a continuous casting slab of a steel which consists essentially of 0.0040 to 0.010% C, 0.05% or less Si, 0.10 to 1.5% Mn, 0.01 to 0.05% P, 0.02% or less S, 0.01 to 0.1% sol.Al, 0.0100% or less N, 0.036 to 0.14% Nb, by weight, and which satisfies the following formula (12):

$$1.1 < (\text{Nb} \times 12)/(\text{C} \times 93) < 2.5 \quad (12),$$

wherein C and Nb denote the content in % by weight of carbon and niobium, respectively;

- (b) preparing a sheet bar by direct rolling or heating the slab from step (a) to a temperature of from 1100 to 1250°C followed by rough rolling;
- (c) finish rolling the sheet bar from step (b) to a total reduction ratio of the pass just before the final pass and the final pass to produce a hot rolled steel sheet of 10 to 40%;
- (d) coiling the hot rolled steel sheet from step (c) at a cooling speed of 15°C/sec or more to a temperature below 700°C, followed by coiling at a temperature of from 620 to 670°C;
- (e) cold rolling the coiled hot rolled steel sheet from step (d) at a reduction ratio of 50% or more, followed by heating the steel sheet at a heating speed of 20°C/sec or more;
- (f) annealing the steel sheet from step (e) at a temperature between 860°C and an Ar₃ transformation temperature, and
- (g) temper rolling the annealed steel sheet from step (f) at a reduction ratio of 0.4 to 1.0%.

11. A high strength cold rolled steel sheet consisting essentially of more than 0.0050% and not more than 0.010% C, 0.05% or less Si, 0.10 to 1.5% Mn, 0.01 to 0.05% P, 0.02% or less S, 0.01 to 0.1% sol.Al, 0.004% or less N, 0.01 to 0.20% Nb, by weight, and satisfying the following formulae (3), (4) and (14):

$$11.0 \leq r + 50.0 \times n \quad (3)$$

$$2.9 \leq r + 5.00 \times n \quad (4)$$

$$1.98 - 66.3 \times C \leq (Nb \times 12) / (C \times 93) \leq 3.24 - 80.0 \times C \quad (14),$$

wherein r denotes the r value, n denotes the n value at 1 to 5% strain, and C and Nb denote the content in % by weight of carbon and niobium, respectively.

12. The high strength steel sheet of claim 11, further containing 0.002% or less B , by weight.

13. A high strength cold rolled steel sheet containing essentially of more than 0.0050% and not more than 0.010% C , 0.05% or less Si , 0.10 to 1.5% Mn , 0.01 to 0.05% P , 0.02% or less S , 0.01 to 0.1% sol. Al , 0.004% or less N , 0.01 to 0.20% Nb , 0.05% or less Ti , and optionally 0.002% or less B , by weight, and satisfying the following formulae (3), (4) and (15):

$$11.0 \leq r + 50.0 \times n \quad (3)$$

$$2.9 \leq r + 5.00 \times n \quad (4)$$

$$1.98 - 66.3 \times C \leq (Nb \times 12)/(C \times 93) + (Ti^* \times 12)/(C \times 48) \leq 3.24 - 80.0 \times C \quad (15),$$

wherein r denotes the r value, n denotes the n value at 1 to 5% strain, Ti^* is not more than 0, and C , S , N , Nb , and Ti denote the content in % by weight of carbon, nitrogen, niobium, and titanium, respectively.

14. The high strength steel sheet of claim 13, further containing 0.002% or less B , by weight.

15. A method for manufacturing a high strength cold rolled steel sheet, comprising the steps of:

(a) preparing a continuous casting slab of a steel which consists essentially of more than 0.0050% and not more than 0.010% C, 0.05% or less Si, 0.10 to 1.5% Mn, 0.01 to 0.05% P, 0.02% or less S, 0.01 to 0.1% sol.Al, 0.004% or less N, 0.01 to 0.20% Nb, by weight, and which satisfies the following formula (14):

$$1.98 \times 66.3 \times C \leq (Nb \times 12)/(C \times 93) \leq 3.24 - 80.0 \times C \quad (14),$$

wherein C and Nb denote the content in % by weight of carbon and niobium, respectively;

(b) preparing a coiled hot rolled steel sheet by finish rolling the slab from step (a) at a total reduction ratio of the pass just before the final pass and the final pass of 60% or less;

(c) cold rolling the hot rolled steel sheet from step (b) and

(d) annealing the sheet from step (c).

16. The method for manufacturing a high strength steel sheet of claim 15, wherein the finish rolling is conducted at a temperature of 870°C or higher, the coiling is conducted at a temperature of 550°C or higher, the cold rolling is conducted at a rolling reduction ratio of 50 to 85%, and the continuous annealing is conducted at a temperature of 780 to 880°C.

17. A method for manufacturing a high strength cold rolled steel sheet, comprising the steps of:

(a) preparing a continuous casting slab of a steel which consists essentially of more than 0.0050% and not more than 0.010% C, 0.05% or less Si, 0.10 to 1.5% Mn, 0.01 to 0.05% P, 0.02% or less S, 0.01 to 0.1 sol.Al, 0.004% or less N, 0.01 to 0.20% Nb, 0.05% or less Ti, by weight, and which satisfies the following formula (15):

$$1.98 \times 66.3 \times C \leq (Nb \times 12)/(C \times 93) + (Ti^* \times 12)/(C \times 48) \leq 3.24 - 80.0 \times C \quad (15),$$

wherein $Ti^* = Ti - (48/14) \times N - (48/32) \times S$, $Ti^* = 0$ when Ti^* is not more than 0, and C, S, N, Nb, and Ti denote the content in % by weight of carbon, nitrogen, niobium, and titanium, respectively;

(b) preparing a coiled hot rolled steel sheet by finish rolling the slab from step (a) to a total reduction ratio of the pass just before the final pass and the final pass of 60% or less;

(c) cold rolling the hot rolled steel sheet from step (b) and

(d) followed by annealing the sheet from step (c).

18. The method of manufacturing a high strength steel sheet of claim 17, wherein the finish rolling is conducted at a temperature of 870°C or higher, the coiling is conducted at a temperature of 550°C or higher, the cold rolling is conducted at a rolling reduction ratio of 50 to 85%, and the continuous annealing is conducted at a temperature of 780 to 880°C